The emission values (obtained per paragraph (a) or (b) of this section, as applicable) used in each calculation of this section shall be rounded in accordance with §86.084–26(a)(6)(iii). The CO_2 values (obtained per paragraph (a) or (b) of this section, as applicable) used in each calculation of this section shall be rounded to the nearest gram/mile. The specific gravity and the carbon weight fraction (obtained per paragraph (c) of this section) shall be recorded using three places to the right of the decimal point. The net heating value (obtained per paragraph (c) of this section) shall be recorded to the nearest whole Btu/lb. These numbers shall be rounded in accordance with the ''Rounding Off Method'' specified in ASTM E 29–67.

(e) For gasoline-fueled automobiles, the fuel economy in miles per gallon is to be calculated using the following equation:

$$mpg=(5174\times10^4\times CWF\times SG)/$$

$$[((CWF\times HC)+(0.429\times CO))+(0.273\times CO_2))\times((0.6\times SG\times NHV)+5471)]$$

Where:

HC=Grams/mile HC as obtained in paragraph (d) of this section.

CO=Grams/mile CO as obtained in paragraph (d) of this section.

CO_2=Grams/mile CO_2 as obtained in paragraph (d) of this section.

CWF=Carbon weight fraction of test fuel as obtained in paragraph (d) of this section.

NHV=Net heating value by mass of test fuel as obtained in paragraph (D) of this section.

SG=Specific gravity of test fuel as obtained in paragraph (d) of this section.

Round the calculated result to the nearest 0.1 miles per gallon.

(f) For diesel automobiles, calculate the fuel economy in miles per gallon of diesel fuel by dividing 2778 by the sum of three terms:

(1) 0.866 multiplied by HC (in grams/miles as obtained in paragraph (d) of this section),

(2) 0.429 multiplied by CO (in grams/mile as obtained in paragraph (d) of this section), and

(3) 0.273 multiplied by CO_2 (in grams/mile as obtained in paragraph (d) of this section).

Round the quotient to the nearest 0.1 mile per gallon.

[51 FR 37851, Oct. 24, 1986]

§ 600.113–93 Fuel economy calculations.

The Administrator will use the calculation procedure set forth in this paragraph for all official EPA testing of vehicles fueled with gasoline, diesel, methanol or natural gas fuel. The calculations of the weighted fuel economy values require input of the weighted grams/mile values for total hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide (CO_2); and, additionally for methanol-fueled automobiles, methanol (CH_3 OH) and formaldehyde (HCHO); and additionally for natural gas-fueled vehicles non-methane hydrocarbons (NMHC) and methane (CH_4) for both the city fuel economy test and the highway fuel economy test. Additionally, the specific gravity, carbon weight fraction and net heating value of the test fuel must be determined. The city and highway fuel economy values shall be calculated as specified in this section. A sample appears in appendix II to this part.

(a) Calculate the weighted grams/mile values for the city fuel economy test for HC, CO and CO_2; and, additionally for methanol-fueled automobiles, CH_3 OH and HCHO; and additionally for natural gas-fueled automobiles NMHC and CH_4 as specified in §86.144 of this chapter. Measure and record the test fuel's properties as specified in paragraph (c) of this section.

(b)(1) Calculate the mass values for the highway fuel economy test for HC, CO and CO_2, and where applicable CH_3 OH, HCHO, NMHC and CH_4 as specified in §86.144(b) of this chapter. Measure and record the test fuel's properties as specified in paragraph (c) of this section.

(2) Calculate the grams/mile values for the highway fuel economy test for HC, CO and CO_2, and where applicable CH_3 OH, HCHO, NMHC and CH_4 by dividing the mass values obtained in paragraph (b)(1) of this section, by the actual distance traveled, measured in miles, as specified in §86.135(h) of this chapter.

(c)(1) Gasoline test fuel properties shall be determined by analysis of a

fuel sample taken from the fuel supply. A sample shall be taken after each addition of fresh fuel to the fuel supply. Additionally, the fuel shall be resampled once a month to account for any fuel property changes during storage. Less frequent resampling may be permitted if EPA concludes, on the basis of manufacturer-supplied data, that the properties of test fuel in the manufacturer's storage facility will remain stable for a period longer than one month. The fuel samples shall be analyzed to determine the following fuel properties:

(i) Specific gravity per ASTM D 1298 (Incorporated by reference as specified in § 600.011–93).

(ii) Carbon weight fraction per ASTM D 3343 (Incorporated by reference as specified in § 600.011–93).

(iii) Net heating value (Btu/lb) per ASTM D 3338 (Incorporated by reference as specified in § 600.011–93).

(2) Methanol test fuel shall be analyzed to determine the following fuel properties:

(i) Specific gravity using either:

(A) ASTM D 1298 (incorporated by reference as specified in § 600.011–93) for the blend or:

(B) ASTM D 1298 (incorporated by reference as specified in § 600.011–93) for the gasoline fuel component and also for the methanol fuel component and combining as follows:

$SG=SG_g\times$volume fraction gasoline$+SG_m\times$volume fraction methanol.

(ii)(A) Carbon weight fraction using the following equation:

$$CWF=CWF_g\times MF_g+0.375\times MF_m$$

Where:

CWF_g=Carbon weight fraction of gasoline portion of blend per ASTM D 3343 (incorporated by reference as specified in § 600.011–93).

MF_g=Mass fraction gasoline=$(GxSG_g)/(GxSG_g+MxSG_m)$

MF_m=Mass fraction methanol=$(MxSG_m)/(GxSG_g+MxSG_m)$

Where:

G=Volume fraction gasoline

M=Volume fraction methanol

SG_g=Specific gravity of gasoline as measured by ASTM D 1298 (Incorporated by reference as specified in § 600.011–93).

SG_m=Specific gravity of methanol as measured by ASTM D 1298 (Incorporated by reference as specified in § 600.011–93).

(B) Upon the approval of the Administrator, other procedures to measure the carbon weight fraction of the fuel blend may be used if the manufacturer can show that the procedures are superior to or equally as accurate as those specified in this paragraph (c)(2)(ii).

(iii) Net heating value (BTU/lb) per ASTM D 240 (Incorporated by reference as specified in § 600.011–93).

(3) Natural gas test fuel shall be analyzed to determine the following fuel properties:

(i) Fuel composition per ASTM D 1945–91, Standard Test Method for Analysis of Natural Gas By Gas Chromatography. This incorporation by reference was approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. Copies may be inspected at U.S. EPA, OAR, 401 M St., SW., Washington, DC 20460, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to: *http://www.archives.gov/federal__register/code__of__federal__regulations/ibr__locations.html.*

(ii) Specific gravity (based on fuel composition per ASTM D 1945).

(iii) Carbon weight fraction based on the carbon contained only in the HC constituents of the fuel=weight of carbon in HC constituents divided by the total weight of fuel.

(iv) Carbon weight fraction of fuel=total weight of carbon in the fuel (*i.e.*, includes carbon contained in HC and in CO_2) divided by total weight of fuel.

(d) Calculate the city fuel economy and highway fuel economy from the grams/mile values for total HC, CO, CO2 and, where applicable, CH3, OH, HCHO, NMHC and CH4 and, the test fuel's specific gravity, carbon weight fraction, net heating value, and additionally for natural gas, the test fuel's composition. The emission values (obtained per paragraph (a) or (b) of this

section, as applicable) used in each calculation of this section shall be rounded in accordance with 40 CFR 86.084–26(a)(6)(iii) or 40 CFR 86.1837–01 as applicable. The CO2 values (obtained per paragraph (a) or (b) of this section, as applicable) used in each calculation of this section shall be rounded to the nearest gram/mile. The specific gravity and the carbon weight fraction (obtained per paragraph (c) of this section) shall be recorded using three places to the right of the decimal point. The net heating value (obtained per paragraph (c) of this section) shall be recorded to the nearest whole Btu/lb.

(e)(1) For gasoline-fueled automobiles, the fuel economy in miles per gallon is to be calculated using the following equation:

$mpg=(5174\times10^4\times CWF\times SG) / [((CWF\times HC) + (0.429\times CO) + (0.273\times CO_2)) \times ((0.6\times SGxNHV)+5471)]$

Where:

HC=Grams/mile HC as obtained in paragraph (d) of this section.

CO=Grams/mile CO as obtained in paragraph (d) of this section.

CO_2=Grams/mile CO_2 as obtained in paragraph (d) of this section.

CWF=Carbon weight fraction of test fuel as obtained in paragraph (d) of this section.

NHV=Net heating value by mass of test fuel as obtained in paragraph (d) of this section.

SG=Specific gravity of test fuel as obtained in paragraph (d) of this section.

(2) Round the calculated result to the nearest 0.1 miles per gallon.

(f)(1) For diesel-fueled automobiles, calculate the fuel economy in miles per gallon of diesel fuel by dividing 2778 by the sum of three terms:

(i) 0.866 multiplied by HC (in grams/miles as obtained in paragraph (d) of this section);

(ii) 0.429 multiplied by CO (in grams/mile as obtained in paragraph (d) of this section); and

(iii) 0.273 multiplied by CO_2 (in grams/mile as obtained in paragraph (d) of this section).

(2) Round the quotient to the nearest 0.1 mile per gallon.

(g) For methanol-fueled automobiles and automobiles designed to operate on mixtures of gasoline and methanol, the fuel economy in miles per gallon is to be calculated using the following equation:

$mpg=(CWF\times SG\times 3781.8) / ((CWF_{exHC}\times HC) + (0.429\times CO) + (0.273\times CO_2) + (0.375\times CH_3 OH) + (0.400\times HCHO))$

Where:

CWF=Carbon weight fraction of the fuel as determined in paragraph (c)(2)(ii) of this section.

SG=Specific gravity of the fuel as determined in paragraph (c)(2)(i) of this section.

CWF_{exHC}=Carbon weight fraction of exhaust hydrocarbons= CWF_g as determined in (c)(2)(ii) of this section (for M100 fuel, CWF_{exHC}=0.866).

HC=Grams/mile HC as obtained in paragraph (d) of this section.

CO=Grams/mile CO as obtained in paragraph (d) of this section.

CO_2=Grams/mile CO_2 as obtained in paragraph (d) of this section.

CH_3 OH=Grams/mile CH_3 OH (methanol) as obtained in paragraph (d) of this section.

HCHO=Grams/mile HCHO (formaldehyde) as obtained in paragraph (d) of this section.

(h) For automobiles fueled with natural gas, the fuel economy in miles per gallon of natural gas is to be calculated using the following equation:

$$mpg_e = \frac{CWF_{HC/NG} D_{NG}\ 121.5}{(0.749)CH_4 + (CWF_{NMHC})NMHC + (0.429)CO + (0.273)(CO_2 - CO_{2NG})}$$

Where:

mpg_e=miles per equivalent gallon of natural gas.

$CWF_{HC/NG}$=carbon weight fraction based on the hydrocarbon constituents in the natural gas fuel as obtained in paragraph (d) of this section.

D_{NG}=density of the natural gas fuel [grams/ft^3 at 68 °F (20 °C) and 760 mm Hg (101.3 kPa)] pressure as obtained in paragraph (d) of this section.

CH_4, NMHC, CO, and CO_2=weighted mass exhaust emissions [grams/mile] for methane, non-methane HC, carbon monoxide, and carbon dioxide as calculated in § 600.113.

CWF_{NMHC}=carbon weight fraction of the non-methane HC constituents in the fuel as determined from the speciated fuel composition per paragraph (c)(2) of this section.

CO_{2NG}=grams of carbon dioxide in the natural gas fuel consumed per mile of travel.
$CO_{2NG}=FC_{NG}\ D_{NG}\ WF_{CO2}$
where:

$$FC_{NG} = \text{cubic feet of natural gas fuel consumed per mile}$$
$$= \frac{(0.749)CH_4 + (CWF_{NMHC})NMHC + (0.429)CO + (0.273)(CO_2)}{CWF_{NG}D_{NG}}$$

where:

CWF_{NG}=the carbon weight fraction of the natural gas fuel as calculated in paragraph (d) of this section.

WF_{CO2}=weight fraction carbon dioxide of the natural gas fuel calculated using the mole fractions and molecular weights of the natural gas fuel constituents per ASTM D 1945.

[59 FR 39654, Aug. 3, 1994; 59 FR 44795, Aug. 30, 1994, as amended at 59 FR 48537, Sept. 21, 1994; 64 FR 23975, May 4, 1999; 69 FR 18803, Apr. 9, 2004]

§ 600.114–08 Vehicle-specific 5-cycle fuel economy and carbon-related exhaust emission calculations.

Paragraphs (a) through (c) of this section apply to data used for fuel economy labeling under subpart D of this part. Paragraphs (d) through (f) of this section are used to calculate 5-cycle carbon-related exhaust emissions values for the purpose of determining optional technology-based CO_2 emissions credits under the provisions of paragraph (d) of §86.1866–12 of this chapter.

(a) *City fuel economy.* For each vehicle tested under §600.010–08(c)(i) and (ii), determine the 5-cycle city fuel economy using the following equation:

$$(1)\ \text{City FE} = 0.905 \times \frac{1}{(\text{Start FC} + \text{Running FC})}$$

Where:

$$\text{(i) Start FC (gallons per mile)} = 0.33 \times \left(\frac{(0.76 \times \text{Start Fuel}_{75} + 0.24 \times \text{Start Fuel}_{20})}{4.1} \right)$$

Where:

$$\text{Start Fuel}_x = 3.6 \times \left(\frac{1}{\text{Bag 1 FE}_x} - \frac{1}{\text{Bag 3 FE}_x} \right)$$